THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:

Sub B1

1. A method for the automated optimization of an injection molding machine set-up process, said machine for manufacturing injection molded parts, including the steps of:

(1) manufacturing one or more parts with said machine;

(2) inspecting said parts for defects;

(3) reducing injection stroke in response to flashing or increasing injection stroke in response to short shots; and

(4) reducing injection velocity in response to flashing or increasing injection velocity in response to short shots, wherein either step (4) is employed after step (3) if step (3) is found to have substantially no effect or substantially no further effect, or step (3) is employed after step (4) if step (4) is found to have substantially no effect or substantially no further effect, thereby reducing said defects.

2. A method for the automated optimization of an injection molding machine set-up process, said machine for manufacturing injection molded parts and including an injection screw and a configurable injection velocity, including the steps of:

(1) manufacturing one of more parts with said machine;

(2) determining an injection pressure profile by measuring injection pressure as a function of elapsed injection time with said machine configured with a substantially constant, desired injection velocity;

(3) measuring injection velocity as a function of elapsed injection time and determining a profile of said measured injection velocity;

(ii) performing at least a partial injection cycle;

(iii) measuring a pressure stroke being the change in displacement of said screw between packing time and said holding time;

(iv) incrementing said holding time;

(v) repeating steps (iii) and (iv) until said pressure stroke stabilizes or a part so produced is acceptable;

(vi) defining a linear relationship between screw displacement and time consistent with screw displacement at said packing time and at said holding time, between said packing time and said holding time;

(vii) defining a gate freeze time as a time of maximum difference between said screw displacement and said linear relationship, thereby providing a value for said gate freeze time from measurements of said screw displacement;

(6) modifying a post-pressure control phase preliminary set-up obtained after (1) to (5) in response to defects detected in said parts manufactured with said preliminary set-up to reduce said defects.

5. ~~34.~~ A method as claimed in claim ~~33~~ 4., wherein step (iii) of step (4) includes determining kickback from measurements of said screw displacement at packing time, including the steps of:

(a) manufacturing one or more parts with said machine;

(b) defining as a first pressure the end of velocity control phase pressure and as a second pressure the holding time pressure;

(c) defining a linear relationship between packing/holding pressure and time consistent with said first pressure and said second pressure, between said first pressure and said second pressure;

(d) defining said packing time as a time of maximum difference between measured melt pressure and said linear relationship, or as the switchover point if measured melt pressure increases after the switchover point;

(e) determining a first screw displacement being the minimum displacement of said screw before said packing time within a packing/holding phase and a second screw displacement being the displacement of said screw at said packing time; and

(f) calculating said kickback from the difference between said first and second screw displacements, thereby allowing a determination of said kickback from measurements of said screw displacement at packing time.

a ~~35~~ 7. A method as claimed in ~~either~~ claim ~~33 or 34,~~ 4. wherein step (5) includes the additional steps of:

(viii) repeating steps (vi) and (vii), and defining an initial solidification time between said packing time and said gate freeze time;

(ix) repeating steps (vi) and (vii), and defining an intermediate solidification time between said packing time and said initial solidification time; and

(x) determining an intermediate pressure from the ratio of the screw displacements at said intermediate time and at said gate freeze time, referenced to said packing time.

a Sub B3 36. A method as claimed in Claim 1 ~~any one of the preceding claims,~~ including:

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determining said machine's velocity control response time, and

employing time steps equal to of greater than said response time.

~~37~~ 3. A method as claimed in claim ~~36~~ 2., wherein said time steps are greater than 1.5 times said response time, and more preferably equal to 2 times said response time.

Sub B3

38. A method as claimed in ~~any one of the preceding claims~~ Claim 1, wherein nozzle melt pressure, injection cylinder hydraulic pressure, forward propelling force applied to said screw, or any other measure proportional to or equal to said nozzle melt pressure, is used as a measure of, in place of, or to determine, injection pressure.

39. A method as claimed in claim 38, wherein said injection cylinder hydraulic pressure is used as a measure of or to determine said injection pressure.

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(4) defining a mean pressure profile from said pressure profile in a regime of substantially constant measured injection velocity profile;

(5) adjusting said velocity profile over at least a portion of an injection velocity phase in response to said pressure profile to reduce differences between said pressure profile and said mean pressure profile, thereby tending to lessen irregularities in said pressure profile.

3. A method as claimed in claim 2, wherein step (5) is performed only in said regime.

a 4. A method as claimed in ~~either~~ claim 2 ~~or 3~~, wherein steps (1) and (2) are repeated a plurality of times to obtain a plurality of measurements of injection pressure profile and said injection pressure profile is determined from a mean of said measurements.

a 5. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 4~~, wherein steps (1) to (5) are repeated a plurality of times, thereby progressively refining said velocity profile.

a 6. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 5~~, wherein step (5) comprises increasing said injection velocity where said pressure profile is less than said mean pressure profile, and decreasing said injection velocity where said pressure profile is greater than said mean pressure profile.

a 7. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 6~~, wherein said mean pressure profile is linear.

a 8. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 6~~, wherein said pressure profile is in the form of a

derivative pressure profile, obtained by differentiating said pressure profile with respect to time.

a 9. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 8,~~ wherein said method includes determining a relationship between the injection velocity and said pressure profile by perturbing said injection velocity about a predetermined velocity.

10. A method as claimed in claim 9, wherein said relationship includes compensation for melt viscosity changes.

11. A method as claimed in claim 10, wherein said viscosity changes include viscosity changes owing to melt pressure and temperature changes.

a 12. A method as claimed in ~~any one of~~ claim~~s~~ 9 ~~to 11~~, wherein said perturbation of said injection velocity is by predetermined amounts.

13. A method as claimed in claim 12, wherein said perturbation of said injection velocity is by ±10% and/or ±20%.

a 14. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 13~~, wherein said pressure profile is derived from hydraulic injection pressure.

a 15. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 13~~, wherein said pressure profile is derived from melt flow pressure.

a 16. A method as claimed in ~~any one of~~ claim~~s~~ 2 ~~to 15~~, wherein said method includes determining a viscosity model

by performing a material test of the injection melt material.

17. A method for the automated optimization of an injection molding machine set-up process, said machine for manufacturing injection molded parts and including an injection screw and a configurable injection velocity, said screw having a displacement, including the steps of:

(1) manufacturing one or more parts with said machine;

(2) defining as a first pressure the end of velocity control phase pressure and as a second pressure the holding time pressure;

(3) defining a linear relationship between packing/holding pressure and time consistent with said first pressure and said second pressure, between said first pressure and said second pressure;

(4) defining said packing time as a time of maximum difference between measured melt pressure and said linear relationship, or as the switchover point if measured melt pressure increases after the switchover point;

(5) determining a first screw displacement being the minimum displacement of said screw before said packing time within a packing/holding phase and a second screw displacement being the displacement of said screw at said packing time; and

(6) calculating said kickback from the difference between said first and second screw displacements, thereby allowing a determination of said kickback from measurements of said screw displacement at packing time.

18. A method for the automated optimization of an injection molding machine set-up process, said machine including an injection screw, including the steps of:

(1) setting an initial packing/holding pressure to a default low pressure;

(2) performing at least a partial injection cycle;

(3) determining kickback from changes in screw displacement during said at least partial injection cycle;

(4) incrementing said initial packing/holding pressure; and

(5) repeating steps (3) and (4) if kickback is unacceptably high until kickback is reduced to a predetermined acceptable level, or initial packing/holding pressure reaches maximum machine pressure.

19. A method as claimed in claim 18, wherein said initial packing/holding pressure is between 5% and 25% of end of velocity control phase pressure, and a substantially uniform packing pressure is used.

20. A method as claimed in claim 19, wherein said initial packing/holding pressure is approximately 10% of end of velocity control phase pressure.

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21. A method as claimed in ~~any one of~~ claim~~s~~ 18 ~~to 20,~~ wherein said initial packing/holding pressure is incremented by between 2% and 25% of said end of velocity control phase pressure.

22. A method as claimed in claim 21, wherein said initial packing/holding pressure is incremented by approximately 5% of said end of velocity control phase pressure.

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23. A method as claimed in ~~any one of~~ claim~~s~~ 18 ~~to 22,~~ including measuring kickback for a plurality of initial packing/holding pressures, predicting an optimum initial packing/holding pressure from said measurements to minimize

kickback, and incrementing said initial packing/holding pressure to said optimum initial packing/holding pressure.

24. A method for the automated optimization of an injection molding machine set-up process, said machine for manufacturing injection molded parts and including an injection screw, including the steps of:

(1) defining a holding time equal to a predetermined default value;

(2) performing at least a partial injection cycle;

(3) measuring a pressure stroke being the change in displacement of said screw between packing time and said holding time;

(4) incrementing said holding time;

(5) repeating steps (3) and (4) until said pressure stroke stabilizes or a part so produced is acceptable;

(6) defining a linear relationship between screw displacement and time consistent with screw displacement at said packing time and at said holding time, between said packing time and said holding time;

(7) defining a gate freeze time as a time of maximum difference between said screw displacement and said linear relationship, thereby providing a value for said gate freeze time from measurements of said screw displacement.

25. A method as claimed in claim 24, including the additional steps of:

(8) repeating steps (6) and (7), and defining an initial solidification time between said packing time and said gate freeze time;

(9) repeating steps (6) and (7), and defining an intermediate solidification time between said packing time and said initial solidification time; and

(10) determining an intermediate pressure from the ratio of the screw displacements at said intermediate time and at said gate freeze time, referenced to said packing time.

a 26. A method as claimed in ~~either~~ claim 24 ~~or 25~~, wherein the value of said holding time employed in step (6) is greater than that defined in step (1) by a factor of between 1 and 3.

a 27. A method as claimed in ~~any one of~~ claim~~s~~ 24 ~~to 26~~, wherein said predetermined default value is the greater of 2 times injection time and one second.

a 28. A method as claimed in ~~any one of~~ claim~~s~~ 24 ~~to 27~~, wherein said stabilization occurs when said pressure stroke changes by less than a predetermined tolerance between successive measurements.

a 29. A method as claimed in ~~any one of~~ claim~~s~~ 24 ~~to 28~~, wherein said holding time is incremented in step (4) by between 5% and 50%.

30. A method as claimed in claim 29, wherein said holding time is incremented in step (4) by approximately 20%.

a 31. A method as claimed in ~~any one of~~ claim~~s~~ 24 ~~to 30~~, wherein said predetermined tolerance is between 2% and 10%.

32. A method as claimed in claim 31, wherein said predetermined tolerance is approximately 5%.

Sub C' 33. A method for the automated optimization of an injection molding machine set-up process, said machine for manufacturing injection molded parts and including an

injection screw and a configurable injection velocity, including the steps of:

(1) determining an optimum fill including:

(i) manufacturing one or more parts with said machine;

(ii) inspecting said parts for defects;

(iii) reducing injection stroke in response to flashing or increasing injection stroke in response to short shots; and

(iv) reducing injection velocity in response to flashing or increasing injection velocity in response to short shots, wherein either step (iv) is employed after step (iii) if step (iii) is found to have substantially no effect or substantially no further effect, or step (iii) is employed after step (iv) if step (iv) is found to have substantially no effect or substantially no further effect, thereby reducing said defects;

(2) determining an optimum injection velocity profile, including:

(i) manufacturing one of more parts with said machine;

(ii) determining an injection pressure profile by measuring injection pressure as a function of elapsed injection time with said machine configured with a substantially constant, desired injection velocity;

(iii) measuring injection velocity as a function of elapsed injection time and determining a profile of said measured injection velocity;

(iv) defining a mean pressure profile from said pressure profile in a regime of substantially constant measured injection velocity profile;

(v) adjusting said velocity profile over at least a portion of an injection velocity phase in response to said pressure profile to reduce differences between said pressure profile and said mean pressure profile, thereby tending to lessen irregularities in said pressure profile.

(3) modifying a post-velocity control phase intermediate set-up obtained after steps (1) and (2) in response to quality defects detected in said parts manufactured with said intermediate set-up to reduce said defects;

(4) a method of reducing kickback to an acceptable level to determine a critical packing/holding pressure, including:

(i) setting an initial packing/holding pressure to a default low pressure;

(ii) performing at least a partial injection cycle;

(iii) determining kickback from changes in screw displacement during said at least partial injection cycle;

(iv) incrementing said initial packing/holding pressure; and

(v) repeating steps (iii) and (iv) if kickback is unacceptably high until kickback is reduced to a predetermined acceptable level, or initial packing/holding pressure reaches maximum machine pressure.

(5) deducing material solidification time from measurements of screw displacement to determine an optimal packing/holding pressure profile, including:

(i) defining a holding time equal to a predetermined default value;